DOCUMENT RESUME

ED 429 103		TM 029 641
AUTHOR	Parshall, Cynthia G.	
TITLE	Audio CBTs: Measuring More through the Use of Speech and Non-Speech Sound.	
PUB DATE	1999-04-00	
NOTE	20p.; Paper presented at the Annual Meeting of the American Educational Research Association (Montreal, Quebec, Canada, April 19-23, 1999).	
PUB TYPE	Reports - Descriptive (141) -- Speeches/Meeting Papers (150)	
EDRS PRICE	MF01/PC01 Plus Postage.	
DESCRIPTORS	*Audio Equipment; *Audiovisual Communications; *Computer Assisted Testing; Educational Technology; Listening Comprehension Tests; *Sound Effects; *Speech; *Test Construction	

ABSTRACT

Most computerized tests are simple applications that make limited use of the technology inherent in computer-delivered examinations. One potentially valuable feature of computer-administered examinations is the ability to play audio files, a function that makes it possible to incorporate sound into computer-based tests. Audio tests allow the potential improvement of measurement in familiar fields and expansion into new fields. This paper addresses some of the characteristics of the audio channel of communication, along with differences between audio and visual forms of communication and differences between speech and nonspeech forms of sound. Then, several specific types of uses for sound in computerized tests are suggested: (1) providing an alternative mode for communicating with the examinee; (2) testing listening skills in traditional areas; (3) testing listening skills in new areas; and (4) incorporating sound into the user interface. Discussion of both experimental and operational audio test is provided. The paper concludes with some cautionary statements and possible research directions. (Contains 29 references.) (Author/SLD)

Audio CBTs: Measuring More through the use of Speech and Non-Speech Sound

Cynthia G. Parshall
University of South Florida

Abstract

In recent years a large number of computerized exams have been developed. The majority of these computerized tests are simple applications that make limited use of the technology inherent in computer-delivered exams. One potentially valuable feature of computer administered exams is the ability to play audio files, a function that makes it possible to incorporate sounds into computer-based tests. Audio tests potentially allow us to improve measurement in familiar fields, and to expand measurement into new ones.

This paper will begin by addressing some characteristics of the audio channel of communication, along with differences between audio and visual forms of communication, and differences between speech and non-speech forms of sound. Next, several specific types of uses for sound in computerized tests will be suggested. These applications are: providing an alternative mode for communicating with the examinee, testing listening skills in traditional areas, testing listening skills in new areas, and incorporating sound into the user interface. Discussion of both experimental and operational audio tests will be provided. The paper concludes with some cautionary statements and possible research directions.

Paper presented at the annual meeting of the American Educational Research Association, Montreal, Canada, April 19-23, 1999.

Audio CBTs: Measuring More through the Use of Speech and Non-Speech Sound

In the last 10-15 years a large number of testing programs have developed computerized exams. The majority of these computerized tests typically use the computer to simply display items and capture responses. There are benefits to computerized administration, including the availability of "walk-in" testing and automatic scoring. However, the technology inherent in computer-delivered exams goes far beyond this limited use of the delivery platform. One valuable feature made easily available in computer administered exams is the ability to play audio files. The availability of this computer function makes it possible to incorporate sound into tests. Although the development of audio exams is somewhat more challenging than that of text-based computer exams, there are also several specific advantages. These advantages include the potential for better sound quality, individual control over the timing of audio prompts, the opportunity to add new innovations to the computer exam, the possibility of making the test administration software easier to learn, and increased measurement efficiency under some testing models.

This paper will address several general areas in which sound may be beneficially included in computerized assessments. First, some current computer uses of the audio channel of communication will be covered, followed by some of the most prominent differences between sound and visuals in computers and between speech and non-speech forms of sound. Next, several specific ways in which sound can be used in computerized tests will be discussed. Examples of both experimental and operational audio tests will be provided. Finally, the paper will conclude with some cautions and some research recommendations.

Use of the audio-channel of communication in computers

People receive a great deal of general life information through what may be termed the audio channel of communication. In fact audio, in the form of speech, is probably the primary means by which people communicate with one another. People also use non-speech sounds to monitor their environments. For example, the wind rising, an engine revving, or footsteps approaching all convey information to listeners about their surroundings. Gaver (1989, p. 67), suggests a model for computer use of sound. "Sound should be used in computers as it is in the world, where it conveys information about the nature of sound-producing events." He further states that sound should be used in computers for three primary reasons. First, because hearing is an additional, largely untapped modality for computer users. Next, because people rely on sound for information in their everyday lives. And finally, because listening can provide information that is complementary to that provided by seeing. That is, sound can be used along with visuals to convey either additional or redundant information.

Several applications of sound in computers are in current use, with different types of audio cues used for each. One type of communication use is evidenced in the computer sounds which provide alarms or warning messages. Buxton (1989), indicates that the purpose of these sounds is to interrupt an ongoing task in order to inform the user of something that requires immediate attention. Hereford and Winn (1994), also indicate that a primary function of computer sound is to keep the user informed about the state of the computer system itself. This may occur through alarms that are generated automatically, or in response to the user's request for information about the system. Either spoken messages or non-speech forms of sound may be used to communicate the information.

Another application of sound is in providing messages related to status and monitoring. For example, Monk (cited in Buxton, 1989) incorporated audio cues to provide status information to users when typing. Users could type in two different modes, and audio was used so that the sound provided when the user pressed the key could have one of two different pitches, depending on the typing mode. The use of this audio information significantly reduced typing errors.

Finally, sound is also used as output from computer programs, as encoded reflections of data. In this approach sound is used to present numerical or quantitative data through patterns of sound. Buxton (1989) provides an example offered by Lunney et al. (1983), in which the spectral information of various chemicals was represented auditorially for blind students. Hereford and Winn (1994) also discuss the general field of audio representations of numerical data in this context. This is a growing field in which audio is used to model multivariate, time series, and other forms of complex, quantitative data.

Kramer (1994), reiterated many of these uses for sound, and pointed out that auditory displays may also have positive effects on users' affective responses. That is, well-designed audition in computer applications may make the applications easier to learn, more engaging, and more capable of conveying subtle qualitative information. Kramer states that these affective benefits of computer sound can create more intuitively meaningful displays. He further suggests that auditory displays used in conjunction with visual displays may provide benefits including non-intrusive enhancement, improved realism of the computer environment, an increase in the perceived quality, increased engagement on the part of the user, and enhanced user learning and creativity.

Audio vs. visual modes

There are obvious differences between auditory and visual communication modes, with each having advantages for certain purposes. Gaver (1989) has indicated that sound exists in time and over space, while visuals exist in space and over time. The two modes differ in the "time" dimension in that sound is dynamic and ephemeral nature, while visuals (at least on computer) tend to be static or even permanent. Because of its dynamic nature, sound has a beginning and an end; and, it can reflect process or change. It is not easy to convey "change" through the visual medium. However, the static nature of visuals gives them an advantage when information needs to be reexamined. In the "space" dimension, the two modes also communicate differently. Visual data can only be received if the user is facing the display, while audio information can be received from any direction. This fact means that sound, or audio, can be useful for conveying information about hidden or obscured processes and events.

In addition to these fundamental differences between the audio and visual channels of communication, there are also differences in how humans process information provided through each (Ballas, 1994). For example, the audio channel draws more on short-term memory, but is better for processing multiple streams of information concurrently (Fitch & Kramer, 1994).

In computer applications, the audio and visual modes can also be used to convey redundant information, in a reinforcing fashion. The two modes can also be used convey complimentary data, with each maximizing its own communicative strength. Sound can be used to communicate information that is difficult to display graphically, it can help to reduce visual clutter in the computer screen, or it can "tell the eyes where to look" (Hereford & Winn, 1994). Visual can be used for purposes such as information that needs to be referred to more than once.

Speech vs. non-speech sound

The majority of the uses described thus far could be provided by either speech or non-speech sounds. Computer applications of speech may consist of brief spoken messages to communicate with the user. Speech may be the preferred communication mode when complex instructions need to be provided, when the user has an insufficient reading level to use written communication, or when the basis of the information relates to spoken data.

For many of the alerting, orienting, and status types of applications discussed above, non-speech sound would be highly appropriate. If these sounds are well selected or designed, they could result in quicker communication, offered in a less intrusive manner, while providing a richer source of information.

Computer applications of non-speech sound use audio in several ways. Specific musical instruments may be mapped to specific computer events. The notes or tones from a given instrument may signify a computer event; and, sonic attributes such as pitch and rhythm may be used to convey changing computer processes. For example, a low tone can be used to represent a large object or file, while a higher tone represents a smaller file. Other applications of non-speech sound use synthesized audio cues to model real-world objects or processes. For example, the sound of a typewriter might be associated with text information, while a camera click is mapped to graphic data.

Uses of sound for computerized assessments

The information and examples above emphasize that most people live audio-rich lives. They hear sounds, both in spoken and non-spoken forms, with great frequency. They extract meaning from these sounds, to inform them about their environments. The information presented to people in audio form is often different from the information available in visual form. Further, research may suggest that information conveyed through the audio mode is cognitively processed in different ways from information communicated through the visual mode. People differ in their development of these skills of listening and cognitively interpreting the sounds around them. Some of these skills may be appropriately included in a wide range of measures of examinees' aptitudes and skills. The next section of this paper will provide a framework for considering uses of sound in computerized assessments.

Applications of sound in computerized assessments

Computerized exams that use audio files are typically administered on computers with internal soundcards and headphones. In a typical application, the audio files are included in the item stem, and the sound is used just as text or graphics might be. Each item sound file is accessed, at the examinee's initiative, by clicking on an onscreen button.

The development of audio computerized assessments may be derived from several distinct purposes. These are: providing an alternative mode for communicating with the examinee, testing listening skills in traditional areas, testing listening skills in new areas, and incorporating sound into the user interface. Examples of tests and other applications in each of these areas are provided below.

Provide an alternative communication mode

There are several specific assessment areas in which both speech and non-speech forms of sound can be beneficially utilized. The first of these areas is that of *providing an alternative mode for communicating* with the examinee. For this type of speech application, instructions, optional help screens, and even items might be provided in audio form. For example, the examinee could click on a button to have an item read aloud. This use of sound would obviously be appropriate for aiding vision-impaired examinees. It could also be beneficial for examinees with a preference or greater strength in the area of auditory learning (as opposed to visual or kinesthetic learning). Finally, it could be useful when testing examinees who have limited English proficiency or poor reading skills. In general, this approach could help reduce a dependence upon text as a means of communicating with the examinee, but would only be appropriate for content areas where reading is not a skill being assessed.

A simple example of this application of sound is provided in Parshall, Stewart, & Ritter (1996). This research study included a sound-based item that had both an audio item stem and audio response options. The stem consisted of the beginning of a spoken sentence, while each response option was a spoken, possible completion to the sentence. This application of listening comprehension assessment demonstrates the greater dependence on short-term memory for listening, as compared to other language skills.

This use of computerized sound to communicate with the examinees was used far more extensively in a recent project for the National Assessment of Educational Progress (NAEP) (Williams, Sweeny, & Bethke, 1997). The project involved the development of audio-CAT software for a NAEP exam. Audio was used in this prototype program as another means of communicating with examinees; the instructions and items on each screen were read aloud as the test progressed. The authors suggest several purposes for this application of computerized sound that may result in improved measurement of student skills. Some of these purposes include: to improve the standardization of tests of students with reading-related deficiencies; to pace test administrations; and to increase the flexibility of test scheduling.

In the past, many computers were equipped with poor sound cards, limited hard drive space, and no headphones, making any use of audio difficult or impossible. With recent improvements in the technology commonly available, the incorporation of audio communication has become much more feasible. This communicative use of speech sound, either alone or with textual information, is still rare in computerized tests. However, it is becoming more prevalent in educational and instructional software. As hardware improves, and as software more frequently provides this accommodation, there may be a greater value placed on audio communication in assessments. While relatively little developmental work has yet occurred for this type of audio test application, it seems an area where growth is likely to occur soon.

[*demonstration*]

Test listening skills in traditional areas

Another general use for sound in computerizes tests is to *test traditional listening skills.* Audio in computerized tests is currently being investigated and developed in those content fields that have previously included listening skills in their assessments. For the most part, this refers to the language and music fields. (Speech sounds are primarily used for language testing, while various specific forms of musical, non-speech sounds are used for music testing.) Paper and pencil standardized assessments in these fields typically include the use of audiocassettes to play item prompts. There are weaknesses in the use of cassette-driven prompts, and conversion of these items and tests to computerized delivery often provides several immediate benefits. Problems with cassette-driven exams include poor quality of the audio and the "assembly-line" administration of prompts. The corresponding benefits include improved sound quality and individual control over the timing of the audio prompts (Parshall, Treder, & Balizet, 1998; Perlman, Berger, & Tyler, 1993)

Prominent examples of computerized language listening exams include work in the area of English listening skills for non-native speakers (e.g., ACT, 1999; ETS, 1998). The computer based version of the TOEFL (Test Of English as a Foreign Language) became operational in 1998 and will completely replace the paper version over the next few years (ETS, 1998). Desirable features of the computerized TOEFL Listening Test include examinees' ability to set the volume, their use of individual headphones, and their increased control over the pace of the test questions. Another computer based listening test for ESL (English as a Second Language) is currently under development at ACT. The ACT ESL Listening test (ACT, 1999) is intended for use as a placement test at post-secondary institutions and will be operational in the Spring of 1999.

A computerized version of the GRE Music Test has been field-tested (Perlman, Berger, Tyler, 1993). This version of the test included two sections that were parallel to the operational GRE Music Test (Harmonic Dictation and Melodic Dictation), as well as two new sections. These new sections, Intervals and Chords, assessed examinees' ability to recognize the intervals and chords played for them through headphones. The authors point out an advantage of computerized administration stating that, "this kind of item is not currently available on the GRE Music Test because the variability of audio reproduction equipment makes playback of intervals and chords from a cassette unacceptably imprecise and thus unfair to test-takers" (Perlman, Berger, & Tyler, 1993, p.4).

Other examples of the development of computerized music tests is in the work of Vispoel and Coffman (1992, 1994). These researchers have investigated the effect of computerized-adaptive testing (CAT) on the assessment of the musical skill of tonal memory (i.e., the ability to remember tonal sequences). They indicate that the general advantage of increased measurement efficiency for CATs is particularly beneficial when administering music-listening tests. This is due to factors in these listening exams that quickly lead to fatigue (e.g., their highly repetitious nature and the extreme examinee concentration required). Vispoel and Coffman (1994) point out that test developers must often respond to the problem of examinee fatigue by offering short exams, thus potentially limiting test reliability and validity. Their results found increased reliability and efficiency, as well as examinee preference, for the CAT version of a tonal memory exam.

Sounds and audio have always been important to fields such as music and language, and assessments in these fields have often included measures of listening skills. The applications presented in this section illustrate some of the advantages available when these listening tests are administered on a computer. Development of audio computerized exams is proceeding rapidly in these areas.

[*demonstration*]

Test listening skills in new areas

Many testing programs that have not measured listening skills in the past, could appropriately include these skills if administration of an audio test were feasible. Computer-administered exams allow developers to *test listening skills in new areas*. These new areas could include expanded areas of content coverage and of types of cognitive skills. Both speech and non-speech sound prompts could be used.

There are numerous potential assessment areas where sound could be used, beyond the traditional subjects of music and language listening skills. As Vispoel, Wang, and Bleiler point out, "a substantial amount of general life experiences and academic activities involves the processing of information that comes to us through listening" (1997, p. 59). In addition, different cognitive skills may be maximized by the visual and aural channels of communication. For example, there is evidence that multiple streams of information can be processed concurrently more easily and accurately when communicated aurally (Fitch & Kramer, 1994).

The Law School Admission Council (LSAC) is currently investigating the development of a listening comprehension test for possible inclusion in their exam program (ACT, 1998). Listening comprehension has always been an important skill for this test population, but without computer administration of the exam, an assessment of the skill has been impractical. Although this application might be superficially similar to ESL testing, there are substantive differences. An ESL test is by definition oriented towards the language proficiency of non-native speakers. The listening comprehension test under consideration for the LSAT would, instead, be oriented towards much higher-order thinking skills, along with a specific content emphasis appropriate for the legal field. For example, the exam might include spoken prompts representing legal arguments or testimony.

Bennett et al. (1997), developed a number of prototype items, in a study of potential uses for multimedia in computerized tests. These multimedia item types included two examples of new areas for assessing listening skills. One of these examples used speech sound in the context of history testing; the second used non-speech sound in the context of medical testing. For the first example, the authors indicate that history tests often require examinees to consider historical documents. An appropriate coverage of the field would include non-text documents and non-print media, as sources of information about the past. The authors provide a computerized item type in which actual, historical radio spots are included in the item stem. These spoken and sung

1-minute spots serve as sources of information for examinee analysis. The Bennett et al. (1997) study also provides an item type that expands content coverage through the use of non-speech sound. The authors point out that some health- and science- related fields require professionals to use various electronic instruments. The ability to interpret the information provided by these devices, including auditory information, is an appropriate skill for test inclusion. The example they provide of this type of item has an item stem that includes a static graphic of an electrocardiogram strip, an animated heart monitor trace, and an audio of the related heart sound.

A study by Fitch and Kramer (1994), also involved the interpretation of audible information from medical equipment. This research study compared students' ability to process information provided through auditory and visual displays. The subjects in this study acted as anesthesiologists, monitoring a "digital patient" and addressing medical complications that arose. An auditory system was designed to parallel a standard visual display of patients' physiological data. Eight physiological variables (e.g., heart rate, body temperature) were communicated in both the visual and auditory displays. The six medical complications were either simple, resulting from a change in a single variable, or multivariate, involving changes in three of the variables. The visual display included labels for each variable's strip chart, and a "visual history" in the form of the previous 15 seconds of activity. These features provided advantages over the auditory display, which was transitory and for which the subjects had to remember the variables' "labels" (e.g., which sound was associated with the patient's breathing rate). However, the auditory information could be received and processed concurrently, while the visual information needed to be looked at and processed sequentially. Results of the study indicated that subjects performed faster and more accurately when using the auditory display rather than the visual display, particularly for multivariate changes. The subjects also reported that, while the labels on the visual display made them feel more confident, after practice the auditory display was easier to use and enabled them to develop an overall "gestalt" perception of the situation.

Outside of testing purposes, sound has been used for a much wider array of computer applications. Sound has been used to represent quantitative information in statistical analysis for multivariate data and time series data, by varying sonic characteristics such as the pitch, volume, and duration of a note, as the quantifiable data varies (see for example, Bly, 1987 and Frysinger & Mezrich, 1987). In fact, the software program *Mathematica* includes the ability to express a mathematical function as a sound (Simon, 1992). There have also been several applications designed to communicate data specifically to the sight impaired. Mansur (1987) mentions the creation of "sound-graphs" in which x-y graphs are expressed to sight impaired users, using a continuously varying pitch to describe a curve. Morrison and Lunney (1987) describe the use of auditory patterns to present the infrared spectrum to visually impaired science students. And, Lunney, et al., (cited in Buxton, 1989) used auditory representation of the spectral information of various chemicals to aid blind science students. Another application of sound is Hardy and Jost's (1996), investigation into the use of music in an instructional science software program. While the music did not significantly improve student achievement, it was associated with higher student affect. Finally, the use of auditory computerized maps has been investigated. Blattner, Papp, and Glinert (1994), used a computerized map of a large building, with floor plans and surrounding areas. Additional information (such as water lines, department names, etc.) was available upon request for many areas within the map. As the cursor was moved over the map, a rich set of audio cues informed the user about this hidden data. For example, the sound of a drum pounding indicated that a building had restricted access; higher levels of restriction were represented by higher pitched, faster pounding.

The variety of applications discussed in this section reinforces how broadly people use listening skills to extract meaning from the sound-producing events around them. Through computerized exams, both speech and non-speech forms of sound can be used to expand the assessment of listening skills to new areas. Speech sounds can be used to aid measurement of such skills as listening comprehension. Items that use speech information can also be developed to assess a variety of cognitive skills, as the historical analysis item provided by Bennett et al. (1997) illustrates. Non-speech sounds can be used to expand assessment of other listening skills. The list of potential applications includes sounds produced by scientific equipment, automobile engines, patients' hearts and lungs, and more. Further, non-speech sounds can be used to represent data in novel ways. Eventually, this data-representational use of audio could be included in assessments, much as charts and graphs are used in many paper-and-pencil tests currently. Preliminary research into these types of audio assessments has begun, but little developmental work appears to be underway.

[*demonstration*]

Incorporate sound into user interfaces

The final general area of application is to *incorporate sound into the user interface*. A growing body of literature in the field of human-computer interface design attests to the importance of utilizing the auditory channel of communication in user interfaces. The utility of non-speech sound in the interface can be illustrated by research on video games, which indicates that experienced users score lower when the sound is turned off (Buxton, 1989). Research has also shown that the response time for auditory information can be less than for visual information (Kramer, 1994). Sounds can help users keep track of multiple ongoing computer processes, they can be used to convey multidimensional information, and sounds used in conjunction with visuals can make a program easier to learn (Gaver, 1994). For tests, this application of sounds has particular implications for simulation exams.

Ballas (1994), offers a set of distinct communication purposes for which sound may be used in the interface. First, sound may be used to get someone's attention. An example might be the error beep a user gets when trying to go past the end of a page. Sound may also be used to refer to something not visually present. Ballas refers to this "pointing" as the "look here" purpose. An example is the tone or sound a computer makes when an e-mail message arrives, thus informing the user even if he or she is not currently viewing that program. Sound may also be used as the aural equivalent of similes or metaphors. That is, a specific sound may be linked to a parameter or event. A sound that is effectively used in this manner may convey information more quickly than speech. A non-computer example is a fire alarm; this is strongly and clearly linked in people's minds with the warning message it sends. Sounds may also be used in computers by synthetically imitating real world sounds. For example, a sound file could be created to imitate the actual sound of water filling a glass. That sound may then be mapped to a computer process, such as loading a file.

Mansur (1987) also offers a set of advantages for the use of audio cues in computer interfaces. First, users do not have to pay direct attention to the audio cues, but rather they can allow their subconscious processes to attend to those cues while they focus on other tasks. Next, users do not need to be within a clear "line-of-sight" of the computer display. Rather, the computer's audio cues can enable the user to monitor ongoing processes, without visual inspections. Additionally, audio cues may be easier to learn than visual cues such as icons. Further, computer screens often have cluttered "visual landscapes" and the use of audio cues may enable the reduction of text messages. Finally, sound can also be used where vision is unavailable. For example, when the user is blind, or when a user is accessing the computer through a phone or other non-screen interface.

A search of the current literature failed to uncover any computerized tests that use sound in the interface, as discussed here. However, there are non-testing applications that may provide useful models for this area of development. Two examples are the SonicFinder and the Audible Web.

The SonicFinder (Gaver, 1989, 1994) is an auditory extension to the Macintosh Finder program. Finder is the Macintosh application that enables users to organize, manipulate, create and delete files (the Windows' programs File Manager and Explorer are similar in function). SonicFinder uses "auditory icons" to communicate information about computer events to the user. Everyday sounds are mapped to user actions and computer events. For example, when a user selects a file SonicFinder plays the sound of an object being "tapped". When a file is copied, SonicFinder plays a "pouring" sound; the pitch of this sound cue increases as the process continues, to indicate the proportion of the file that has been copied. Gaver (1994) suggests that adding auditory cues to this interface provides the advantages of increasing users' direct engagement with the modeled world of the interface, and of increasing flexibility for getting information about that world.

An auditory interface for a web browser was developed by Albers and Bergman (1995). The Audible Web provides non-speech audio cues for three specific purposes. First, audio is used to provide feedback on user actions. This type of interface feedback informs the users that their actions were noted and responded to by the system. For example, the Audible Web includes a "click" sound when a menu item is selected and a short "pop" sound when a scroll bar item is chosen. Audio cues are also designed to provide feedback about links to aid users' navigation choices. For example, the approximate size of a linked file can be gauged by the pitch of a piano note, before a user decided whether or not to access the link. Finally, audio information is provided to allow users to monitor the process of data transfer (e.g., a page or graphic loading onto the screen). That is, once a user accesses a linked file, a series of low-volume clicks and pops is played to indicate that data is being transferred. An error in the data transfer is signified by the sound of breaking glass. Albers and Bergman suggest that auditory interfaces are particularly useful when minimal screen space is available, or when text/graphical communication may be invasive or intrusive. Advantages include: an increase in the perceived quality of the application on the part of the user; heightened user engagement with the program; and, reinforcement of the information provided through the visual mode.

Several additional auditory interfaces are described in Cohen (1994) and in Gaver (1994). The Sound Shark provides auditory icons for a large-scale, collaborative system that models a virtual physics lab. Another application, Khronika, is a server-based system that notifies users about both scheduled and unscheduled events. The notifications may be provided in the form of graphics, auditory cues, or text-to-speech. Other examples include RAVE, which also uses video, ARKOLA and EAR. Development of all of these auditory environments has included an emphasis on selecting audio cues that are either intuitive and self-evident, or easily learned and remembered.

In most of the applications discussed in this section, sound is used primarily to provide cues that are redundant to the visual information. Even here, the audio cues can provide some additional information (e.g., the size of a linked file), and provide some information in a better way (e.g., the sound of breaking glass when a data transfer error occurs). However, Gaver (1989, p. 82) has emphasized the "largely unexplored potential for sound to convey relevant information that is not effectively conveyed by visual means." Fitch and Kramer (1994, p. 324) also state that perhaps "it is time to consider the idea that certain types of information might be better perceived through auditory than through visual channels." As more work is conducted in these areas, important new applications where audio provides better communication than visuals are likely to become increasingly evident.

The audio interface applications described in this section are all outside of the testing arena. Even in the general field of computer applications, this use of sound is at a relatively young stage of research and development. Nevertheless, the advantages and importance of this line of work seem clear, and interest is very high. More realistic, immersive simulated environments could become the norm for many software programs. If this occurs, it could be that users will come to expect both speech and non-speech audio communications from their computer applications. (Over time, mouse use and graphical user interfaces have become so standard that most testing applications automatically provide point-and-click interactions, and it is expected that examinees prefer them.) Even if this level of ubiquitous sound use does not occur, there are likely to be many assessment areas where a fuller use of sound in the interfaces is valuable, particularly for applications such as simulation-based exams. Additional work is clearly needed, both in specific content areas and in the general area of cognitive processing, to bring about successful assessments of this type. However, the potential improvements in expanded and improved measurement may be worth the effort.

[*demonstration*]

Summary

The use of sound in computerized tests is at a very early stage of evolution. The development of audio exams is occurring most rapidly in the traditional listening skills areas of music and languages. Growth is also likely in the area of providing audio as an additional form of communication with examinees. This use of audio is currently being included in some general educational and instructional programs. Development of audio exams assessing listening skills in new areas may occur more gradually. However, for those fields where listening is an important, but previously unassessed skill, the value for this type of test is easily seen. As exams in these fields are moved to the computer administration mode, listening components may be added to the assessments. Finally, the development of audio computer interfaces for assessment will probably move much more slowly than the other testing applications of sound. When work in this area does begin, it is perhaps most likely to be in simulation based exams.

Cautions

It will be important to add audio in appropriate ways. While research has shown that audio can aid visually impaired users and examinees, a dependence upon audio can clearly disadvantage hearing impaired individuals. Furthermore, the goal should certainly be to improve communication and assessment, and not to simply add sounds in what may be intrusive or pointless ways. It will also be important to identify and use appropriate sounds. While evidence suggests that well constructed audio cues can be easy to learn, this is at least in part because they are have been carefully mapped to some process or meaning. If the purpose of the sound, or the sound itself is not clear, than these advantages may not be found. In addition, people appear to have far stronger reactions to sounds than to visuals; poorly chosen sounds can be worse than useless, they can be intrusive and annoying.

Research Recommendations

A wide range of research is needed to fully support the use of audio in computerized tests. More information is needed about the functioning of the computer interface, and even more critically, the relevant cognitive processes that are active in a given content area.

The present state of knowledge suggests that some types of information are better communicated through audio than through visual or textual means. One important area of research for testing applications will be to identify and verify critical uses of audio communication in computerized exams (perhaps, auditory instructions, help screens, or more).

A related research area will be to investigate the cognitive differences in processing auditory and visual information. Research on the substantive ways in which these two modes differ may expand the set of examinee abilities included in assessments.

Research is also needed on the inclusion of audio in the user interface. While this application probably has the greatest implications for simulation based exams, other uses can also be investigated. Audio feedback could be included in the interface of a simple, multiple-choice computerized test. An investigation could be conducted into whether this use of sound provided the benefits suggested. For example, if it helped users learn to use the test software more quickly, it would enable examinees to spend more attention on taking the test than on learning to use it, and thus potentially improve test validity.

It appears that the use of audio may make possible the measurement of examinee skills, abilities, and cognitive processes beyond those assessed in traditional, static, text-based test programs. It is likely that some efforts will need to be made in the field before they the full range of potential uses becomes evident. Gaver (1994, p. 427) has pointed out the value of working with, and experimenting on the use of audio. He stated, "By building these systems, using them ourselves, and observing others use them, we have gained a great deal of valuable information about their utility, their problems, and issues for their design."

References

ACT, Inc. (1998). *Assessing listening comprehension: A review of recent literature relevant to an LSAT Listening Component*. Unpublished manuscript, LSAC, Newton, PA.

ACT, Inc. (1999). *Technical Manual for the ESL Exam*. Iowa City, IA: Author.

Albers, M. C., & Bergman, E. (1995). The Audible Web: Auditory enhancements for Mosaic. In *CHI '95 Proceedings: Conference on Human Factors in Computing Systems: Mosaic of Creativity* (http://ACM.ORG/sigchi/chi95/Electronic/documnts/shortppr/mca_bdy.htm). New York, NY: ACM.

Ballas, J. A. (1994). Delivery of information through sound. In G. Kramer (Ed.), *Auditory Display* (pp. 79-94). Reading, MA: Addison-Wesley.

Bennett, R. E., Goodman, M., Hessinger, J., Ligget, J., Marshall, G., Kahn, H., & Zack, J. (1997). *Using multimedia in large-scale computer-based testing programs* (Research Rep. No. RR-97-3). Princeton, N. J.: Educational Testing Service.

Blattner, M. M., Papp, A. L., & Glinert, E. P. (1994). Sonic enhancement of two-dimensional graphics displays. In G. Kramer (Ed.), *Auditory Display* (pp. 447-470). Reading, MA: Addison-Wesley.

Bly, S. A. (1987). Communicating with sound [1985 ACM Panel discussion (W. Buxton, Moderator)]. In R. M. Baecker & W. A. S. Buxton (Eds.), *Readings in Human-Computer Interaction: A Multidisciplinary Approach* (pp. 420-424). San Mateo, CA: Morgan Kaufman.

Buxton, W. (1989). Introduction to this special issue on nonspeech audio. *Human-Computer Interaction, 4,* 1-9.

Cohen, J. (1994). Monitoring background activities. In G. Kramer (Ed.), *Auditory Display* (pp. 499-531). Reading, MA: Addison-Wesley.

Educational Testing Services. (1998). *Computer-Based TOEFL Score User Guide*. Princeton, NJ: Author.

Fitch, W. T., & Kramer, G. (1994). Sonifying the Body Electric: Superiority of an auditory over a visual display in a complex, multivariate system. In G. Kramer (Ed.), *Auditory Display*, (pp. 307-325). Reading, MA: Addison-Wesley.

Frysinger, S. P., & Mezrich, J. J. (1987). Communicating with sound [1985 ACM Panel discussion (W. Buxton, Moderator)]. In R. M. Baecker & W. A. S. Buxton (Eds.), *Readings in Human-Computer Interaction: A Multidisciplinary Approach* (pp. 420-424). San Mateo, CA: Morgan Kaufman.

Gaver, W. W. (1989). The SonicFinder: An interface that uses auditory icons. *Human-Computer Interaction, 4,* 67-94.

Gaver, W. W. (1994). Using and creating auditory icons. In G. Kramer (Ed.), *Auditory Display* (pp. 416-446). Reading, MA: Addison-Wesley.

Hardy, R. D., & Jost, K. L. (1996). *The use of music in the instructional design of multimedia.* Paper presented at the national convention of the Association for Educational Communications and Technology, Indianapolis.

Hereford, J., & Winn, W. (1994). Non-speech sound in human-computer interaction: A review and design guidelines. *Journal of Educational Computing Research, 11*, 211-233.

Kramer, G. (1994). An introduction to auditory display. In G. Kramer (Ed.), *Auditory Display* (pp. 1-77). Reading, MA: Addison-Wesley.

Lunney, D., Morrison, R. C., Cetera, M. M., Hartness, R. V., Mills, R. T., Salt, A. D., & Sowell, D. C. (1983). A microcomputer-based laboratory aid for visually impaired students. *IEEE Micro, 3,* 19-31.

Mansur, D. L. (1987). Communicating with sound [1985 ACM Panel discussion (W. Buxton, Moderator)]. In R. M. Baecker & W. A. S. Buxton (Eds.), *Readings in Human-Computer Interaction: A Multidisciplinary Approach* (pp. 420-424). San Mateo, CA: Morgan Kaufman.

Monk, A. (1986). Mode errors: A user-centered analysis and some preventive measures using keying-contingent sound. *International Journal of Man-Machine Studies, 24,* 313-327.

Morrison, R. C., & Lunney, D. (1987). Communicating with sound [1985 ACM Panel discussion (W. Buxton, Moderator)]. In R. M. Baecker & W. A. S. Buxton (Eds.), *Readings in Human-Computer Interaction: A Multidisciplinary Approach* (pp. 420-424). San Mateo, CA: Morgan Kaufman.

Parshall, C. G., Stewart, R, & Ritter, J. (1996, April). *Innovations: Sound, graphics, and alternative response modes*. Paper presented at the annual meeting of the National Council on Measurement in Education, New York.

Parshall, C. G., Treder, D. W., & Balizet, S. (1998, July). *Using an audio computer-based progress exam to test the listening skills of non-native speakers*. Paper presented at the Simposio Sobre Tecnologias Educativas: Enseñanza para el Siglo XXI (Symposium on Educational Technology: Teaching for the 21st Century), Mèrida, Venezuela.

Perlman, M., Berger, K., & Tyler, L. (1993). *An application of multimedia software to standardized testing in music*. (Research Rep. No. 93-36) Princeton, NJ: Educational Testing Service.

Simon. B. (1992, March). Mathematica for Windows: Reshaping math software with graphics and sound. *PC Magazine*, pp. 37, 44.

Vispoel, W. P., & Coffman, D. (1992). Computerized adaptive testing of music-related skills. *Bulletin of the Council for Research in Music Education, 112*, 29-49.

Vispoel, W. P., & Coffman, D. D. (1994). Computerized-adaptive and self-adaptive music-listening tests: Psychometric features and motivational benefits. *Applied Measurement in Education, 7,* 25-51.

Vispoel, W. P., Wang, T., & Bleiler, T. (1997). Computerized adaptive and fixed-item testing of music listening skill: A comparison of efficiency, precision, and concurrent validity. *Journal of Educational Measurement, 34,* 43-63.

Williams, V. S. L., Sweeny, S. F., & Bethke, A. D. (1997). *A prototype audio-CAT for the National Assessment.* (Final Report No. RTI 51U-6889) Prepared for: National Center for Educational Statistics, NAEP Redesign CFDA No. 84.902A.

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

ERIC

TM029641

Reproduction Release

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Audio CBTs: Measuring more through the use of speech and non-speech sound	
Author(s): Parshall, C. G.	
Corporate Source: University of South Florida	Publication Date: AERA, April 99

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, Resources in Education (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign in the indicated space following.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY ______ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY ______ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY ______ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
Level 1	Level 2A	Level 2B
☑	☐	☐
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g. electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche, or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Signature: Cynthia G. Parshall	Printed Name/Position/Title: Cynthia G. Parshall, Psychometrician	
Organization/Address: Institute for Instructional Research & Practice, University of South Florida	Telephone: 813/974-1256	Fax: 813/974-5132
	E-mail Address: parshall@seaweed.coedu.usf.edu	Date: 3/19/99

III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC, or, if you wish ERIC to cite the availability of the document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents that cannot be made available through EDRS.)

Publisher/Distributor:
Address:
Price:

IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant this reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

Name:
Address:

V. WHERE TO SEND THIS FORM:

Send this form to the following ERIC Clearinghouse:	
ERIC Clearinghouse on Assessment and Evaluation **1129 Shriver Laboratory (Bldg 075)** **College Park, Maryland 20742**	**Telephone: 301-405-7449** **Toll Free: 800-464-3742** **Fax: 301-405-8134** **ericae@ericae.net** **http://ericae.net**

EFF-088 (Rev. 9/97)